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U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
A. C. TRUE, Director.

THE NUTRITION INVESTIGATIONS OF THE OFFICE OF EXPERIMENT STATIONS AND THEIR RESULTS.

By

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[Reprint from Annual Report of the Office of Experiment Stations for the year ended June 30, 1906.]

5101—07

GOVERNMENT PRINTING OFFICE, 1907.

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In recent years the experimental study of various problems connected with food and nutrition of man and domestic animals has been actively followed in the United States. Some of the work has been of a very practical nature and some has been highly technical. Though they are not commonly considered together, the studies of the food of man and animals have much in common, for of course the physiological laws which underlie the nutrition of the animal body are essentially the same for all warm-blooded animals. Then, too, many experimental methods are common to both classes of investigation, at least as regards the principles on which they are based, though it is needless to say that the details and the manner of using the methods are varied. A considerable part of this inquiry into the various food problems has been carried on in connection with the agricultural experiment stations which have been established in the United States during the last thirty years and are now in operation in all the States and Territories of the Union with the exception of the Philippines. In the earlier years of the experiment station movement in this country investigations which had to do with food in a broad sense were quite largely confined to work with domestic animals. However, early in their history many of the experiment stations studied the nutritive value of grains and other foods used by man as well as various problems connected with the storage, handling, and transportation of food products and related questions, and after a time a number of them included studies of the food of man in their regular work.

Studies of the nutritive value of different foods have been conducted in the United States for a great many years, but the first systematic attempt to investigate such problems dates from the investigations carried on by Prof. W. O. Atwater for the Smithsonian Institution and for the Massachusetts bureau of labor and statistics, and the nutrition investigations of the Office of Experiment Stations are a natural outgrowth of this enterprise, as Professor Atwater, who was the first director of the Office of Experiment Stations, early sought to include this work with the other lines followed.

In 1894–5 Congress provided a special appropriation which enabled the Secretary of Agriculture to prosecute inquiries in this direction and

the work was later assigned to the Office of Experiment Stations. From the first the plan of cooperation with experiment stations, agricultural colleges, and other educational institutions and with philanthropic associations was followed in the belief that such a course, in which each party was a contributor, would yield the most satisfactory returns for a given investment. The sums which have been appropriated by Congress for the nutrition investigations of the Department of Agriculture have been since the beginning as follows:

Appropriations for nutrition investigations.

Fiscal year.	Amount	Fiscal year.	Amount.
1894–95	$10,000	1901–2	$20,000
1895–96	15,000	1902–3	20,000
1896–97	15,000	1903–4	20,000
1897–98	15,000	1904–5	20,000
1898–99	15,000	1905–6	20,000
1899–1900	15,000	1906–7	20,000
1900–1901	17,500		

These amounts have been increased by contributions from other sources, some of which are not easily estimated in terms of money, since they consist in large part of the use of laboratories, apparatus, chemicals, and other facilities for research, the counsel and help of experts, and similar services. Some of the States, notably Connecticut and Illinois, have made special appropriations for the study of problems relating to the food and nutrition of man, and a considerable number of the experiment stations, educational institutions, philanthropic associations, and private individuals have donated sums of money to promote cooperative research.

Until ill health prevented, Prof. W. O. Atwater was the chief of the nutrition investigations and was responsible for the plans and general oversight of the work. A large amount of experimental work was also carried on under his immediate supervision in Professor Atwater's laboratory in the chemical department of Wesleyan University, the Connecticut (Storrs) Experiment Station being a generous contributor to the enterprise. As time progressed and the correspondence and other business arrangements connected with the nutrition investigations developed, it became evident that the enterprise as a whole should be centered in Washington, and at the beginning of the fiscal year 1906–7 a division of nutrition investigations was established in the Office of Experiment Stations.

SCOPE OF THE WORK.

In the earlier years of the nutrition investigations many analyses of American food materials were made, as the data regarding the chemical composition of such food materials were comparatively limited. Information along this line has, however, accumulated very rapidly

as a result of studies carried on by different investigators, and data are now so abundant that studies of proximate composition of food materials no longer constitute one of the lines of work followed in the cooperative nutrition investigations of the Office. Dietary studies—that is, studies of the kinds and amount of food purchased, eaten, and wasted—were early recognized as of great importance, and a large number have been made in private families, schools, colleges, public institutions, and elsewhere under a variety of conditions and in widely separated regions.

No matter what its composition, food is of no use to the body unless it is digested, and it is natural that experiments should have been undertaken with a variety of food materials to learn how thoroughly they were assimilated by the body and to ascertain the effect of various methods of preparation and combination upon thoroughness of digestion. Furthermore, it is supposable that the occupation in which the subject is engaged, whether active or sedentary, may have an influence upon the work of the digestive tract, and this question has also been studied. Many questions regarding the thoroughness of assimilation may be investigated with the aid of ferments under conditions which approximate those in the body, and a large number of such artificial digestion experiments have been carried on, particularly in studying ease and rapidity of digestion, a question which is very different from thoroughness of digestion, though the two are often confused in popular discussions of the subject.

Variations in the excretion of nitrogen have long been regarded as indications of changes taking place in the body, and it has been a general custom of physiologists to study the balance of income and outgo of nitrogen. Such studies have formed a part of the nutrition investigations of the Department. Much more useful as a means of studying the food requirements of the body and other questions are determinations of the balance of carbon, oxygen, and hydrogen, as well as nitrogen, and determinations of the balance of income and outgo of energy. Such studies necessitate special apparatus, and a respiration calorimeter has been devised which is admirably adapted to the purpose for which it is designed and which, it seems fair to say, is so far the most perfect instrument of its type. The respiration calorimeter is of such a size that a man may remain in comparative comfort in the respiration chamber for a number of hours or days, and the measurements of income and outgo of matter and energy may be made with great accuracy. The determination of energy values of food and excretory products necessitates some special apparatus for measuring the heat of combustion of these materials, and in connection with the nutrition investigations a bomb calorimeter has been perfected which has proved very satisfactory.

Numerous studies have been undertaken of the changes brought about and losses sustained when foods of different sorts are cooked in different ways, the principal food materials included in this work being bread, vegetables, and meat. Canning and preserving fruits and vegetables may be regarded as special applications of cooking processes and much experimental work has been done along these lines with a view to the elaboration of satisfactory household methods. In general, it may be said that in connection with the different lines of work mentioned it has been necessary to devise and perfect experimental methods, as at the time the investigations were first undertaken the amount of work which had been done in the United States and elsewhere along similar lines was not very considerable.

The same period which has witnessed the development of the nutrition enterprise has seen a great interest aroused in the teaching of home economics in schools and colleges, and nutrition is one of the main divisions included in this subject. As the nutrition investigations have supplied a great deal of data which the teachers of home economics must use and as the Office was already closely identified with other educational enterprises, it was almost inevitable that the pedagogics of nutrition should receive attention and become an increasingly important part of the nutrition enterprise.

The preparation of reports of investigations and popular summaries has also constituted an important feature of the work.

The following table shows in graphic form the character and extent of the investigations which have been undertaken up to July 1, 1906:

Cooperative nutrition investigations of the Office of Experiment Stations.

Line of work.	Number of investigations.	Number of publications.
Dietary studies	485	20
Digestion experiments	675	18
Experiments on the effect of different circumstances on the income and outgo of nitrogen	500	(a)
Respiration calorimeter experiments	88	6
Experiments on effects of cooking on meats	157	3
Experiments on losses in cooking vegetables	12	1
Investigations on changes and losses in bread making	3	2
Special investigations	5	2
Compilation of data	.....	4
Preparation of popular summaries	.....	30

a These investigations are included in the publications reporting digestion experiments.

In addition to the popular summaries and the technical bulletins included in the above table, a large number of briefer summaries have been prepared which have appeared in the series of farmers' bulletins entitled "Experiment Station Work," and for the last ten years the subject of food and nutrition has constituted one of the divisions of the Experiment Station Record, and abstracts of the current literature of the subject have appeared regularly.

DISTRIBUTION OF THE WORK.

The cooperative investigations of the Office of Experiment Stations have been carried on in a considerable number of institutions in 21 States and Territories. The following brief summary arranged alphabetically by States shows the localities in which the investigations have been prosecuted and the names of the cooperating institutions:

Alabama.—Tuskegee Normal and Industrial Institute.

California.—University of California and California Agricultural Experiment Station.

Connecticut.—Wesleyan University, Storrs Experiment Station, and Connecticut Bible Normal College.

Georgia.—University of Georgia.

Hawaii.—Hawaii Agricultural Experiment Station.

Illinois.—Hull House, Chicago; Lewis Institute, Chicago; University of Illinois and University of Chicago.

Indiana.—Purdue University.

Maine.—University of Maine and Maine Agricultural Experiment Station.

Maryland.—Baltimore Board of Charities and several public institutions in Baltimore.

Massachusetts.—Massachusetts Institute of Technology, Boston; School of Housekeeping, Boston; Wellesley College, Harvard University, and Bible Normal College, Springfield.

Minnesota.—University of Minnesota and Minnesota Agricultural Experiment Station.

Missouri.—University of Missouri.

New Jersey.—New Jersey Agricultural Experiment Station.

New Mexico.—New Mexico College of Agriculture and Mechanic Arts and New Mexico Agricultural Experiment Station.

New York.—Cornell University, Ithaca; Association for the Improvement of the Condition of the Poor, New York; New York Christian Alliance, New York, and Columbia University, New York.

North Dakota.—North Dakota Agricultural College.

Ohio.—Lake Erie College.

Pennsylvania.—Philanthropic institutions, Philadelphia; Drexel Institute, Philadelphia, and Pennsylvania College for Women, Pittsburg.

Tennessee.—University of Tennessee.

Vermont.—Vermont Agricultural Experiment Station.

Virginia.—Hampton Normal and Agricultural Institute and University of Virginia, Charlottesville.

Mention should also be made here of other investigations, which though not strictly a part of the cooperative inquiry yet are so closely related to it that they may be included in the summary. On behalf of the New York State Commission in Lunacy an extended series of dietary studies was undertaken in New York hospitals for the insane, under Professor Atwater's direction, as were also studies at the Elmira Reformatory, New York. For a number of years a sum of money has been granted by the Carnegie Institution for nutrition investigations at Middletown, Conn., and the work has been so planned that it supplemented the investigations there carried on under the auspices of this Department.

SOME RESULTS OF THE NUTRITION INVESTIGATIONS.

It is difficult to measure the results of scientific investigations in the usual units, particularly when the data sought are in a considerable degree educational. When, as in the case of nutrition investigations, the results have also a very decided practical value and are capable of application on every farm and in every home, such an estimate of values is even more difficult. An idea of the returns given for the money invested may be gathered from the fact that since the institution of the investigations in 1894–95, the total sum appropriated for this work has been $222,500. The total number of dietary studies made has been 485, each study having covered from three to thirty days. The total number of digestion experiments with men has been 675, and in general each experiment has covered three days. Supplementing this phase of the work 300 artificial digestion experiments have also been made. The total number of metabolism experiments has been 500, of which 88 have been experiments with the respiration calorimeter. These latter experiments have covered a total of 270 experimental days. The total number of cooking experiments has been nearly 200.

In addition to the above, a number of miscellaneous experiments have been made for the study of special problems, and the studies of pedagogical problems have likewise been numerous.

As a result of the work 30 farmers' bulletins and 50 technical bulletins have been published, as well as numerous short popular summaries.

In earlier statements[a] which have been published, attention has been called to some of the important results of nutrition investigations and at this time reference will be made to some of the later work.

DISTRIBUTION OF FOOD MATERIALS IN THE DIET.

Food habits vary greatly in different regions of the United States, and articles of diet which are popular in one region are almost unknown in another. There are certain staple foods, however, such as meat and bread, which are obviously common to all regions, and it is generally conceded that such staple foods are the principal sources of nutritive material in the diet. The proportion of nutrients and energy which different classes of food materials supply in the diet of the average American family is a matter of considerable interest, and the table which follows and which is based on the results of 376 dietary studies gives results which may be regarded as fairly conclusive.

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[a] Some Results of Dietary Studies in the United States. Reprinted from U. S Dept. Agr. Yearbook, 1898.

Scope and Results of the Nutrition Investigations of the Office of Experiment Stations. Reprinted from U. S. Dept. Agr., Office of Experiment Stations Ann. Rpt. 1901.

Investigations on the Nutrition of Man in the United States. U. S. Dept. Agr., Doc. No. 713.

Proportion of nutrients furnished by different food materials in average of 376 American dietary studies.

Food materials.	Total food material.	Protein.	Fat.	Carbohydrates.
ANIMAL FOODS.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Beef and veal	7.2	16.7	13.2	.....
Lamb and mutton	.9	2.1	2.6	.....
Pork, including lard	7.2	9.3	42.1	.....
Poultry	.7	1.6	.9	.....
Total meats	16.0	29.7	58.8	.....
Fish	1.8	3.5	1.0	.....
Eggs	2.1	4.1	2.9	.....
Butter	1.6	.3	16.6	.....
Cheese	.3	1.0	1.1	.....
Milk and cream	16.5	8.7	8.0	3.6
Total dairy products	18.4	10.0	25.7	3.6
Unclassified animal foods	.2	.2	.2	.3
Total animal foods	38.5	47.5	88.6	3.9
VEGETABLE FOODS.				
Wheat flour, patent	12.2	19.4	1.5	25.6
Wheat flour, entire	.1	.1	.....	.2
Wheat flour, graham	.1	.2	.....	.2
Wheat preparations	.3	.5	.1	1.0
Wheat bread, patent	5.8	8.1	1.6	12.4
Wheat bread, entire	.....	.....	.....	.1
Wheat bread, graham	.1	.1	.....	.2
Crackers	.3	.5	.5	1.0
Sweet cakes, etc	.6	.8	.9	1.4
Corn meal and flour	8.7	10.1	3.8	13.7
Corn preparations	.2	.2	.1	.4
Oatmeal and preparations	.5	1.0	.5	1.1
Rice	.3	.3	.....	.9
Rye	1.3	1.6	.1	3.1
Barley and buckwheat	.1	.1	.....	.5
Total cereals	30.6	43.0	9.1	61.8
Sugar, molasses, etc	5.4	.....	.....	17.5
Starch (prepared)	.....	.....	.....	.1
Dried legumes	1.0	2.9	.2	1.7
Fresh legumes	.6	.4	.....	.3
Tubers and yams	12.5	3.8	.3	8.3
Other vegetables	6.2	1.6	.5	1.7
Total vegetables	20.3	8.7	1.0	12.0
Fresh fruits	3.8	.3	.3	2.5
Dried fruits	.6	.2	.1	1.2
Total fruits	4.4	.5	.4	3.7
Nuts	.....	.....	.1	.....
Unclassified vegetable foods	.5	.1	.2	.6
Total vegetable foods	61.2	52.3	10.8	95.7
Miscellaneous food materials	.3	.2	.6	.4
Total food materials	100.0	100.0	100.0	100.0

As will be seen from the above table, meats and poultry furnish not quite twice as much protein as all other animal foods together, and of the meats beef and veal together furnish in round numbers half of the protein supplied by the group of total meats. As sources of fat, meats furnish a little over twice as much as is supplied by all the other animal foods, pork being the most important of the meats in this respect. Dairy products are the most important animal

foods aside from meats, milk and cream together furnishing 10 per cent of the total protein and 26 per cent of the total fat of the diet. The animal foods furnish less than 5 per cent of the total carbohydrates of the diet, this important food constituent being supplied almost exclusively by the cereals and other vegetable foods. It will be seen that the animal and vegetable foods are about equal in rank as sources of protein, some 52 per cent of the total protein being supplied by the vegetable foods, and the cereals furnishing 43 per cent are the most important members of the group. Little fat is furnished by vegetable foods, the group as a whole supplying only 11 per cent of the total amount in the diet.

DIETARY STUDIES.

As a result of the numerous dietary studies and kindred investigations, which form a part of the nutrition investigations, dietary standards have been proposed which experience has shown are satisfactory guides for the purchase of food supplies for families and institutions. These so-called standards have been reported and discussed in earlier publications[a] and need not be referred to further. How far these so-called standards represent the physiological demands of the body is a question which needs further investigation.

In the case of actual energy requirements it is obvious that the amount required can not be less than the total quantity given off by a fasting man performing no external muscular work. This question and similar phases of the subject have been studied with the respiration calorimeter and the results are referred to on page 368. As regards actual protein requirements, it seems very probable that the quantity varies with different physiological conditions and other circumstances and further investigations are needed before final deductions are warranted.

The dietary studies have furnished a number of factors showing the amounts of food required by children of different ages and by women as compared with a man at moderate muscular work. These factors have been referred to in detail elsewhere.[a]

In earlier work no account was taken of the variations in food requirements in old age as compared with middle life. A number of the more recent dietary studies have been made in old-age homes and similar institutions, and as a result of this work the conclusion has been reached that the energy requirements of men and women past middle life are practically the same per kilogram body weight, and that such persons require nine-tenths as much food as an adult man in full vigor who is engaged in moderate muscular work.

[a] U. S. Dept. Agr., Farmers' Bul. 142.

One of the most obvious applications of the results of the nutrition investigations is found in the commissary department of large public institutions and in general in the feeding of large groups. Available data and experimental methods make it possible to examine the diet under such conditions and pass upon its adequacy and real value, as related to its cost, in much the same way that an expert accountant can pass upon the financial condition of any business enterprise. It is often possible to point out ways of checking waste and diminishing cost, or of improving the character of the food without additional expense.

As an illustration of the importance of nutrition investigations in public institutions it may be said that as a result of studies carried on for several years in large institutions in one of the Eastern States very considerable savings were affected, while the diet as a whole was improved. An examination of the accounts of one of these institutions showed a per capita saving of 13.7 per cent in the second year of the work over the per capita expenditure for the first year, and this reduction is all the more striking in view of the fact that during the year in which it was made the price of a large number of the food materials used had advanced very materially. A similar saving was effected in a number of institutions, and it seems fair to conclude that the results were applicable to all the public institutions in the State. The total cost of the food supplied to all the institutions in the State at the time the studies were made was considerably over $1,000,000, and if a similar saving had been made in all these institutions the total saving would have been more than $150,000 per year.

In general, it may be said that the importance of applying the results of the nutrition investigations in the providing of food for public institutions, in the provisioning of camps and expeditions, in regulating the commissary department of the Army and Navy, and in determining the diet in schools and colleges, as well as in the home, is becoming more generally recognized each year as is shown by the many applications made to the Department for information along these lines and the numerous requests for aid in carrying on experimental dietary studies and other investigations.

DIGESTION EXPERIMENTS.

It has long been a custom with physiologists to calculate the digestibility of food of various kinds with the aid of average factors when it was not possible to determine digestibility by actual experiments. Since it is the food digested and not the food eaten which is of special importance to the body, it is very often desirable in discussing the results of dietary studies to consider digestible nutrients rather than total nutrients, and the data desired may be readily

calculated by the use of factors. The following table shows the factors for calculating the digestibility and fuel value of nutrients in a number of single foods and groups of food materials, which have been deduced from the large number of digestion experiments carried on in connection with the nutrition investigations of the Office. A comparison of calculated results with data obtained from natural digestion experiments has shown that these factors are reasonably accurate, and it seems fair to say that they are more satisfactory than any which have been hitherto proposed.

Factors for calculating digestibility and fuel value of nutrients in food materials.

Classes of food materials.	Protein.				Fat.				Carbohydrates.				Energy-proportion of total actually available.
	Proportion of total in mixed diet.	Digestibility.	Fuel value per gram.		Proportion of total in mixed diet.	Digestibility.	Fuel value per gram.		Proportion of total in mixed diet.	Digestibility.	Fuel value per gram.		
			Total nutrients.	Digestible nutrients.			Total nutrients.	Digestible nutrients.			Total nutrients.	Digestible nutrients.	
	P. ct.	*P. ct.*	*Cals.*	*Cals.*	*P. ct.*	*P. ct.*	*Cals.*	*Cals.*	*P. ct.*	*P. ct.*	*Cals.*	*Cals.*	*P. ct.*
Meat and fish	33	97	4.27	4.40	63	95	9.03	9.50	4	98	3.82	3.90	87
Eggs	4	97	4.37	4.50									89
Dairy products	10	97	4.27	4.40	26	95	8.79	9.25					93
Annual food (of mixed diet)	47	97	4.27	4.40	89	95	8.93	9.40	4	98	3.82	3.90	89
Cereals	43	85	3.87	4.55	11	90	8.37	9.30	62	98	4.11	4.20	91
Legumes (dried)	3	78	3.47	4.45					2	97	4.07	4.20	83
Sugars									18	98	3.87	3.95	98
Starches										98	4.11	4.20	98
Vegetables	6	83	3.11	3.75					10	95	3.99	4.20	91
Fruit	1	85	3.36	3.95					4	90	3.60	4.00	88
Vegetable food (of mixed diet)	53	85	3.74	4.40	11	90	8.37	9.50	96	97	4.03	4.15	92
Total food (of mixed diet)	103	92	4.05	4.40	100	95	8.93	9.40	100	97	4.03	4.15	91

The table shows that the different food materials and groups of food materials vary greatly in the thoroughness with which they are assimilated. Meats of different sorts, as ordinarily prepared for the table, and indeed animal foods as a whole, are more completely digested than the common vegetable foods. Considering foods as a whole, 96 per cent of the total organic material is digested and 91 per cent of the energy is available. In other words, on an average the body rejects only about 4 per cent of the nutrients and about 9 per cent of the energy supplied by the food.

RESPIRATION CALORIMETER EXPERIMENTS.

In conducting experiments of various kinds it is often very desirable to know every requirement of a subject engaged in muscular work. The exact measurement of energy expenditure is time consuming and requires special apparatus, but with the aid of the factors deduced from the large number of experiments which have been made with

the respiration calorimeter the desired data may be calculated approximately. In the experiments referred to all grades of muscular activity have been tested, from the quiet of a fasting subject in deep sleep to the excessive muscular work of a professional bicycle rider whose powers were taxed to the utmost. When muscular work was performed other than that involved in the ordinary motions essential to eating and drinking and moving about in the respiration chamber, the muscular exercise consisted in operating a bicycle-like apparatus. The ease with which the wheel turned, and hence the severity of the work could be regulated, and the total amount of work performed could be accurately measured.

It will be remembered that in discussions of body energy the amount of work is measured in terms of heat, the calorie being the commonly accepted heat unit. It should also be said that under usual conditions the total heat output during a given period affords an indication of the muscular activity of the body. When the body is quiet the heat output is small and when it is active the heat output is correspondingly larger, and the same is true of the carbon dioxid output. The average results of the experiments showing the output of carbon dioxid and heat for the body under the different conditions indicated are summarized in the table following, and with the aid of such data the total carbon dioxid and heat output, and hence the total energy output of the body, may be calculated.

Average normal output of carbon dioxid and heat from the body.

Conditions of muscular activity.	Average quantities per hour.	
	Carbon dioxid.	Heat.
	Grams.	*Calories.*
Man at rest, sleeping	25	05
Man at rest, awake, sitting up	35	100
Man at light muscular exercise	55	170
Man at moderately active muscular exercise	100	2 0
Man at severe muscular exercise	150	4 0
Man at very severe muscular exercise	210	600

It will be seen that the output not only of heat but also of carbon dioxid is very nearly proportional to the amount of muscular work. As an example of the way in which the data included in the table may be used for calculating the carbon dioxid and heat output under varying degrees of muscular activity the following may be cited:

If a man sleeps eight hours per day, we may say that the carbon dioxid output during this period is approximately eight times the hourly amount eliminated during sleep by the average subject, or 8 by 25 = 200. If he is at very severe muscular labor for eight hours, the carbon dioxid output would correspond to eight times the hourly amount for very severe work, that is, 8 by 210 = 1,680. And if the

remaining eight hours of the day were devoted to going to and from work, eating, sitting, etc., corresponding, say, to six hours of rest and two hours at light muscular exercise, the carbon dioxid output will be six times the average amount eliminated per hour at rest, that is, 6 by 35 = 210 grams, and two times the amount given off at light work, 2 by 55 = 110 grams. The total for the twenty-four hours would obviously be the sum of the quantities mentioned above, or 2,200 grams. The heat eliminated in the twenty-four hours by men at very severe work may be likewise calculated by multiplying the time devoted to sleep, work, etc., by the average hourly output. In eight hours at sleep he would eliminate 520 calories (8 by 65 = 520); in eight hours at work, 4,800 calories (8 by 600 = 4,800); in six hours of rest, 600 calories (6 by 100 = 600); and in two hours at light exercise, 340 calories (2 by 170 = 340); making a total for the twenty-four hours of 6,260 calories.

The investigations made in connection with the respiration calorimeter have furnished the most accurate records yet available of the normal diurnal variations in body temperature. A summary of this work and a discussion of the results which apply to problems of ventilation and other topics have been included in a recent publication of the Department.[a]

SPECIAL STUDIES OF CEREALS, LEGUMES, MEAT, FRUIT, AND NUTS.

As regards the results of special investigations, particular interest attaches to the studies of the digestibility and nutritive value of cereal products. The extensive investigations which have been made with different grades of flour have shown that when ground from the same lot of wheat the standard patent flour furnishes slightly less protein and mineral matter than the coarser flours but surpasses them in digestibility, and so may be fairly said to have a somewhat higher nutritive value pound for pound. The coarser flours have a somewhat laxative effect, which is commonly attributed to their bran content, and are useful in the diet in this way and for the variety which they give. In general, it may be said that flours of all sorts are nutritious and wholesome and among the most important constituents of the diet.

The investigations with cereal breakfast foods have shown that this class of goods so much used at the present time may constitute an important source of nutritive material, and that although the individual products differ less among themselves in nutritive material than is commonly supposed, as a whole they are nutritious and directly comparable with flours of various types. The breakfast foods in which the coarser part of the grain has been removed have

[a] U. S. Dept. Agr. Yearbook, 1904, p. 205.

much the same digestibility and total nutritive value pound for pound as the finer flours, while those which retain the outer portions of the grain are more directly comparable with whole wheat and graham flours.

Studies of the nutritive value of dried legumes have formed an important part of the nutrition investigations and have shown that in general these foods are well assimilated and may be made very important and economical sources of protein in the diet. Particular interest attaches to the results obtained with cowpeas, an important crop in the Southern States but little known in other regions. This legume, which possesses a distinctive and palatable flavor and may be cooked in a variety of ways, has been shown to closely resemble the more common beans and peas in digestibility and nutritive material, and is well worthy of general use.

The investigations with fruits and nuts have demonstrated that these materials may be fairly regarded as economical sources of nutrients and energy, even when used in fairly large amounts, and indicate that an appreciation of their real food value will greatly increase the amounts consumed.

The extended investigations which have to do with the losses sustained when meat is cooked in various ways have shown that the loss is smaller in boiling than in roasting or frying. In general, the principal constituent lost in cooking is water, though when meat is boiled the amount of total substance which is removed may be as great as 20 per cent. Generally speaking, the smaller the cut the greater the percentage loss in cooking. The investigations have also shown that it is possible to control temperature and other factors so that uniform results may be obtained in the preparation of meat in the household or where it is cooked in larger quantities.

PEDAGOGICS OF NUTRITION.

An examination in detail of the courses in home economics given at the fifty or more agricultural colleges and other institutions receiving Government aid will show that the instruction in nutrition is very largely based on the results of the food investigations which have been carried on under the auspices of this Department. The same is true of the courses of instruction along this line given in high schools, universities, medical colleges, and other American educational institutions. The number of text-books on food and nutrition has been comparatively limited, and at present a large proportion of teachers giving instruction in these subjects depend on Department publications to supply this need. It is worthy of note that the newer text-books and handbooks of nutrition and physiological chemistry draw very largely upon the data furnished by these nutrition investigations, and that the authors almost uniformly acknowledge their indebtedness to the Department work and their appreciation of it. A similar

use is made in other countries of the results o
gations, and as an instance may be cited the
of a considerable proportion of the nutrition publications in connection with the general movement for the dissemination of information regarding food and nutrition in that country.

As a part of the nutrition enterprise special attention is being paid to the collection of data of use to teachers and its arrangement in pedagogical form, the work being carried on along the lines which have proved so successful in formulating courses in other branches of agricultural education.

CONCLUSION.

Attention has been directed in the foregoing pages to the lines which have been especially followed in carrying on the nutrition investigations of the Office of Experiment Stations, and some of the results of this important agricultural enterprise have been pointed out.

As regards their origin, all foods, both animal and vegetable, are agricultural products. In the past the farmer was very commonly the distributor of his products, and the foods passed directly from the farm to the consumer. At the present day this is much less common, and most of the foodstuffs become articles of commerce before they reach the housewife, and in many cases are manufactured products, as they must pass through the mill, the dairy, the packing house, or other manufacturing institution before they are ready for use.

Briefly stated, the chief object of the nutrition investigations is to secure the better utilization of these varied food products, and it seems fair to say that much has already been accomplished along this line. The housewife in the farm home or in the town has at her disposal a large amount of data regarding the composition, digestibility, and nutritive value of foods and their relative economy as sources of nutrients and energy, which will aid her in making a good use of her available food supply, and will help her to prepare for her family a diet which is rational and suited to their physical needs. At the same time, the investigations have demonstrated the importance of having the daily fare palatable, well cooked, and attractive, and have shown how such requirements may be met without undue cost. The manufacturer and the distributer of food products are likewise helped by the dissemination of knowledge concerning food materials and their preparation, for such knowledge means a greater development of the important commercial enterprises in which they are interested. And finally, the farmer, the cattle raiser, the dairyman, the market gardener, and all who are direct producers of food supplies are benefited, as a knowledge of the important facts regarding the comparative value of different foods can not fail to bring about improved standards of living, and hence a greater demand for the foodstuffs which they alone can supply.

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